AMENDMENT NO. 1 JANUARY 2016
TO
IS 11939 : 1996 AUTOMOTIVE VEHICLES — STEERING CONTROL SYSTEMS — IMPACT PROTECTION REQUIREMENTS AND METHODS OF MEASUREMENT

(*Second cover page, Foreword, para* 6) **—** Substitute 'Annex D' *for* 'Annex A'.

(*Page* 1, *clause* **1.2**) **—** Substitute the following for existing clause:

'**1.2** This standard is applicable to vehicles andto the electrical power train operating on high voltage as well as the high voltage components and systems which are galvanically connected to the high voltage bus of the electrical power train, of motor vehicles of category M_1 and N_1, with a maximum permissible mass up to 1 500 kg, fitted with steering control.'

(*Page* 1, *clause* **3.7**) **—** Substitute the following for existing clause:

'**3.7 Passenger Compartment**

3.7.1 Passenger compartment with regard to occupant's protection means the space for occupant accommodation bounded by the roof, floor, side walls, doors, outside glazing, front bulkhead and the plane of the rear seat back support.

3.7.2 Passenger compartment for electric safety assessment means the space for occupant accommodation, bounded by the roof, floor, side walls, doors, outside glazing, front bulkhead and rear bulkhead, or rear gate, as well as by the electrical protection barriers and enclosures provided for protecting the occupants from direct contact with high voltage live parts.'

(*Page* 3, *clause* **3.16**) **—** Insert the following new clauses after **3.16**:

'3.17 Vehicle type means a category of motor vehicles which do not differ in such essential respects as:

a) *Vehicle powered by an internal combustion engine*:

1) The structure, dimensions, lines and constituent materials of that part of the vehicle forward of the steering control; and
2) Unladen weight of the vehicle.

b) *Vehicle powered by an electric engine*:

1) The structure, dimensions, lines and constituent materials of that part of the vehicleforward of the steering control;
2) The locations of the Rechargeable Energy Storage Systems (REESS), in so far asthey have a negative effect on the result of the impact test prescribed in this Standard; and
3) Unladen weight of the vehicle.

3.18 High Voltage

High voltage means the classification of an electric component or circuit, if its working voltage is between 60 V and 1 500 V direct current (d.c.) or between 30 V and 1 000 root means square V alternating current (a.c. rms).

3.19 Rechargeable Energy Storage System (REESS)

Rechargeable energy storage system (REESS) means rechargeable energy storage system which provides electrical energy for propulsion.

3.20 Electrical Protection Barrier

Electrical protection barrier the part providing protection against any direct contact to the high voltage live parts.

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3.21 Electrical Power Train

Electrical power train means the electrical circuit which includes the traction motor(s), and may also include the REESS, the electrical energy conversion system, the electronic converters, the associated wiring harness and connectors, and the coupling system for charging the REESS.

3.22 Live Parts

Live parts means conductive part(s) intended to be electrically energized in normal use.

3.23 Exposed Conductive Part

Exposed conductive part means the conductive part which can be touched under the provisions of the protection IPXXB and which becomes electrically energized under isolation failure conditions. This includes parts under a cover that can be removed without using tools.

3.24 Direct Contact

Direct contact means the contact of persons with high voltage live parts.

3.25 Indirect Contact

Indirect contact means the contact of persons with exposed conductive parts.

3.26 Protection IPXXB

Protection IPXXB means protection from contact with high voltage live parts provided by either an electrical protection barrier or an enclosure and tested using a Jointed Test Finger (IPXXB) as described in **B-4.**

3.27 Working Voltage

Working voltage means the highest value of an electrical circuit voltage root-mean-square (rms), specified by the vehicle manufacturer, which may occur between any conductive parts in open circuit conditions or under normal operating conditions. If the electrical circuit is divided by galvanic isolation, the working voltage is defined for each divided circuit, respectively.

3.28 Coupling System for Charging the Rechargeable Energy Storage System (REESS)

Coupling system for charging the rechargeable energy storage system (REESS) means the electrical circuit used for charging the REESS from an external electrical power supply including the vehicle inlet.

3.29 Electrical Chassis

Electrical chassis means a set made of conductive parts electrically linked together, whose electrical potential is taken as reference.

3.30 Electrical Circuit

Electrical circuit means an assembly of connected high voltage live parts which is designed to be electrically energized in normal operation.

3.31 Electric Energy Conversion System

Electric energy conversion system means a system that generates and provides electrical energy for electrical propulsion.

3.32 Electronic Converter

Electronic converter means a device capable of controlling and/or converting electrical power for electrical propulsion.

3.33 Enclosure

Enclosure means the physical part enclosing the internal units and providing protection against any direct contact.

3.34 High Voltage Bus

High voltage bus means the electrical circuit, including the coupling system for charging the REESS that operates on a high voltage.

3.35 Solid Insulator

Solid insulator means the insulating coating of wiring harnesses provided in order to cover and prevent the high voltage live parts from any direct contact. This includes covers for insulating the high voltage live parts of connectors; and varnish or paint for the purpose of insulation.

3.36 Automatic Disconnect

Automatic disconnect means a device that when triggered, separates the electrical energy sources from the rest of the high voltage circuit of the electrical power train galvanically.

3.37 Open Type Traction Battery

Open type traction battery means a type of battery requiring liquid medium and generating hydrogen gas released to the atmosphere.'

(*Page* 5, *clause* **7.1**) **—** Insert the following new clause after **7.1**:

'**7.1.1** Additionally vehicles, equipped with electrical power train, shall meet requirements specified in Annex A. This could be demonstrated in a separate frontal impact test at the request of the vehicle manufacturer after validation by the Test Agency, given that the electric components do not influence the driver's protection performance of the vehicle type as defined in this standard.'

(*Page* 6, *clause* **7.2.4.4**) **—** Insert the following new clauses after **7.2.4.4:**

'**7.2.4.5** *Electrical power train adjustment*

7.2.4.5.1 The REESS shall be at any state of charge, which allows the normal operation of the power train as recommended by the manufacturer.

7.2.4.5.2 The electrical power train shall be energized with or without the operation of the original electrical energy sources (for example engine-generator, REESS or electric energy conversion system), however;

7.2.4.5.3 By the agreement between Test Agency and vehicle manufacturer, it shall be permissible to perform the test with all or parts of the electrical power train not being energized in so far as there is no negative influence on the test result. For parts of the electrical power train not energized, the protection against electrical shock shall be proved by either physical protection or isolation resistance and appropriate additional evidence.

7.2.4.5.4 In the case where an automatic disconnect is provided, at the request of the vehicle manufacturer, it shall be permissible to perform the test with the automatic disconnect being triggered. In this case it shall be demonstrated that the automatic disconnect would have operated during the impact test. This includes the automatic activation signal as well as the galvanic separation considering the conditions as seen during the impact.'

(*Page* 8, *Annex* A) — Insert the following new Annexes A to C and renumber the existing 'Annex A' as 'Annex D':

ANNEX A

(*Clause* 7.1.1)

REQUIREMENTS FOR ELECTRICAL POWER TRAIN OPERATING ON HIGH VOLTAGE, THE HIGH VOLTAGE COMPONENTS AND SYSTEMS WHICH ARE GALVANICALLY CONNECTED TO THE HIGH VOLTAGE BUS OF THE ELECTRICAL POWER TRAIN

A-1 REQUIREMENTS FOR VEHICLES EQUIPPED WITH ELECTRICAL POWER TRAIN

A-1.1 Following the test conducted in accordance with the procedure defined in **7**, the electrical power train operating on high voltage and the high voltage components and systems, which are galvanically connected to the high voltage bus of the electrical power train, shall meet the following requirements.

A-1.1.1 *Protection Against Electrical Shock*

After the impact test, at least one of the four criteria specified in **A-1.1.1.1** to **A-1.1.1.4.2** shall be met. If the vehicle has an automatic disconnect function or device(s), that galvanically divide the electrical power train circuit during driving condition, at least one of the following criteria shall apply to the disconnected circuit or to each divided circuit individually after the disconnect function is activated. However, criteria defined in **A-1.1.1.4** shall not apply, if more than a single potential of a part of the high voltage bus is not protected under the conditions of protection IPXXB. In the case that the test is performed under the condition that part(s) of the high voltage system are not energized, the protection against electrical shock shall be proved by either **A-1.1.1.3** or **A-1.1.1.4** for the relevant part(s).

A-1.1.1.1 *Absence of high voltage*

The voltages V_b, V_1 and V_2 of the high voltage buses ≤ 30 $V_{a.c.}$ or 60 $V_{d.c.}$ as specified in Annex B.

A-1.1.1.2 *Low electrical energy*

The total energy (TE) on the high voltage buses < 2.0 Js when measured according to the test procedure and formula specified in **B-3**(a). Alternatively the total energy (TE) may be calculated by the measured voltage V_b of the high voltage bus and the capacitance of the X-capacitors (C_x) specified by the vehicle manufacturer according to formula given in **B-3** (b).

The energy stored in the Y-capacitors (TE_{y1}, TE_{y2}) shall also be less than 2.0 J. This shall be calculated by measuring the voltages V_1 and V_2 of the high voltage buses and the electrical chassis, and the capacitance of the Y-capacitors specified by the manufacturer according to formula given in **B-3**(c).

A-1.1.1.3 *Physical protection*

For protection against direct contact with high voltage live parts, the protection IPXXB shall be provided. In addition, for protection against electrical shock, which could arise from indirect contact, the resistance, between all exposed conductive parts and the electrical chassis, < 0.1 Ω when there is current flow of at least 0.2 A. This requirement is satisfied, if the galvanic connection has been made by welding.

A-1.1.1.4 *Isolation resistance*

The criteria specified in the **A-1.1.1.4.1** and **A-1.1.1.4.2** below shall be met. The measurement shall be conducted in accordance with **B-5**.

A-1.1.1.4.1 *Electrical power train consisting of separate d.c. or a.c. buses*

If the a.c. high voltage buses and the d.c. high voltage buses are galvanically isolated from each other, isolation resistance between the high voltage bus and the electrical chassis (Ri as defined in **B-5**) shall have a minimum value of 100 Ω/volt of the working voltage for DC buses, and a minimum value of 500 Ω/volt of the working voltage for AC buses.

A-1.1.1.4.2 *Electrical power train consisting of combined d.c. and a.c. buses*

If the a.c. high voltage buses and the d.c. high voltage buses are galvanically connected, isolation resistance between the high voltage bus and the electrical chassis (R_i as defined in **B-5**) shall have a minimum value of 500 Ω/V of the working voltage.

However, if the protection IPXXB is satisfied for all a.c. high voltage buses or the a.c. voltage is equal or less than 30 V after the vehicle impact, the isolation resistance between the high voltage bus and the electrical chassis (R_i as defined in **B-5**) shall have a minimum value of 100 Ω/V of the working voltage.

A-1.1.2 *Electrolyte Spillage*

In the period from the impact until 30 min after, no electrolyte from the REESS shall spill into the passenger compartment, and no more than 7 percent of electrolyte shall spill from the REESS except open type traction batteries outside the passenger compartment. For open type traction batteries, no more than 7 percent with a maximum of 5.0 litre shall spill outside the passenger compartment. The vehicle manufacturer shall demonstrate compliance in accordance with **B-6**.

A-1.1.3 *REESS Retention*

REESS located inside the passenger compartment shall remain in the location in which they are installed and REESS components shall remain inside REESS boundaries. No part of any REESS that is located outside the passenger compartment for electrical safety assessment shall enter the passenger compartment during or after the impact test. The vehicle manufacturer shall demonstrate compliance in accordance with **B-7**.

ANNEX B

(*Clauses* 3.25, A-1.1.1.1, A-1.1.1.2, A-1.1.1.4, A-1.1.1.4.1, A-1.1.1.4.2, A-1.1.2 *and* A-1.1.3)

TEST PROCEDURES FOR THE PROTECTION OF THE OCCUPANTS OF VEHICLES OPERATING ON ELECTRICAL POWER FROM HIGH VOLTAGE AND ELECTROLYTE SPILLAGE

B-0 This Annex describes test procedures to demonstrate compliance to the electrical safety requirements of Annex A. For example, megohmmeter or oscilloscope measurements are an appropriate alternative to the procedure described below for measuring isolation resistance. In this case it may be necessary to deactivate the on-board isolation resistance monitoring system.

Before the vehicle impact test conducted, the high voltage bus voltage (V_b) (*see* Fig. 5) shall be measured and recorded to confirm that it is within the operating voltage of the vehicle as specified by the vehicle manufacturer.

B-1 TEST SET UP AND EQUIPMENT

If a high voltage disconnect function is used, measurements are to be taken from both sides of the device performing the disconnect function.

However, if the high voltage disconnect is integral to the REESS or the energy conversion system and the high-voltage bus of the REESS or the energy conversion system is protected according to protection IPXXB following the impact test, measurements may only be taken between the device performing the disconnect function and the electrical loads.

The voltmeter used in this test shall measure d.c. values and have an internal resistance of at least 10 MΩ.

B-2 The following instructions may be used, if voltage is measured:

After the impact test, determine the high voltage bus voltages (V_b, V_1, V_2) (*see* Fig. 5). The voltage measurement shall be made not earlier than 5 seconds but not later than 60 s after the impact. This procedure is not applicable, if the test is performed under the condition where the electrical power train is not energized.

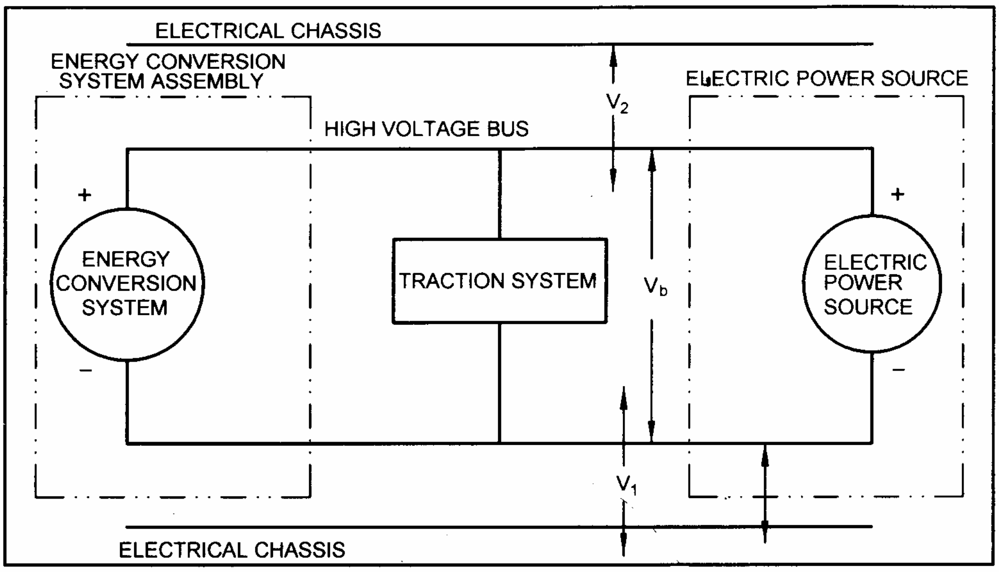


FIG. 5 MEASUREMENT OF V_b, V_1, V_2

B-3 ASSESSMENT PROCEDURE FOR LOW ELECTRICAL ENERGY

Prior to the impact a switch S_1 and a known discharge resistor R_e is connected in parallel to the relevant capacitance (*see* Fig. 6).

Not earlier than 5 s and not later than 60 s after the impact, the switch S_1 shall be closed while the voltage V_b and the current I_e are measured and recorded. The product of the voltage V_b and the current I_e shall be integrated over the period of time, starting from the moment when the switch S_1 is closed (t_c) until the voltage V_b falls below the high voltage threshold of 60 V d.c. (t_h). The resulting integration equals the total energy (TE), in J:

a) $$TE = \int_{tc}^{th} V_b \times I_e dt$$

When V_b is measured at a point in time between 5 seconds and 60 seconds after the impact and the capacitance of the X-capacitors (C_x) is specified by the vehicle manufacturer, total energy (*TE*) shall be calculated according to the following formula:

b) $TE = 0.5 \times C_x \times (V_b^2 - 3\,600 \text{ Volt})$

When V_1, V_2 (*see* Fig. 5) are measured at a point in time between 5 seconds and 60 seconds after the impact and the capacitances of the Y-capacitors (C_{y1}, C_{y2}) are specified by the vehicle manufacturer, total energy (TE_{y1}, TE_{y2}) shall be calculated according to the following formulas:

c) $TE_{y1} = 0.5 \times C_{y1} \times (V_1^2 - 3\,600)$
$TE_{y2} = 0.5 \times C_{y2} \times (V_2^2 - 3\,600)$

This procedure is not applicable, if the test is performed under the condition where the electrical power train is not energized.

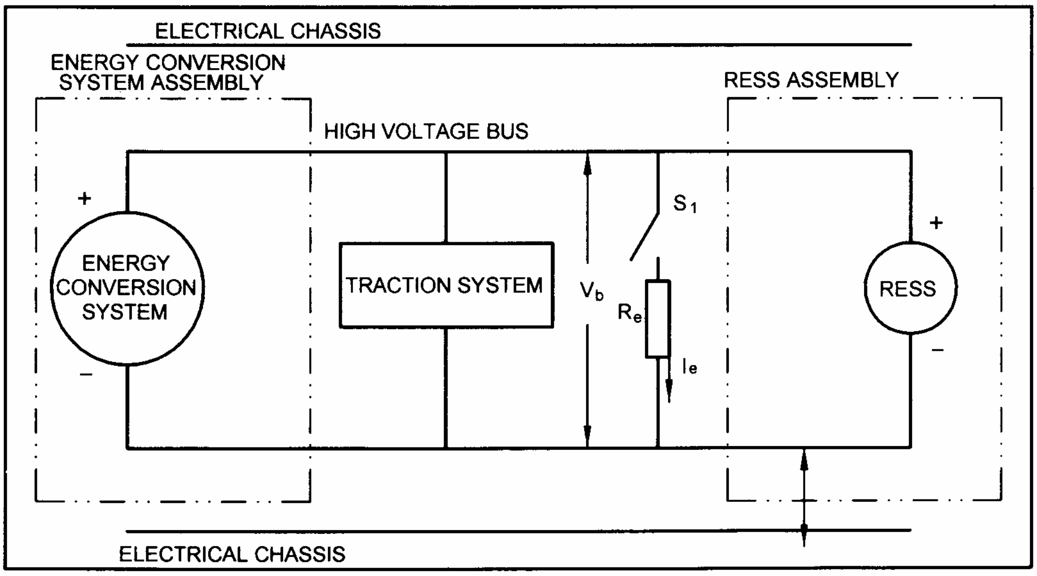


FIG. 6 E.G. MEASUREMENT OF HIGH VOLTAGE BUS ENERGY STORED IN X-CAPACITORS

B-4 PHYSICAL PROTECTION

Following the vehicle impact test, any parts, surrounding the high voltage components shall be, without the use of tools, opened, disassembled or removed. All remaining surrounding parts shall be considered part of the physical protection.

The Jointed Test Finger (JTF) described in Fig. 9 shall be inserted into any gaps or openings of the physical protection with a test force of 10 N ±10 percent for electrical safety assessment. If partial or full penetration into the physical protection by the Jointed Test Finger occurs, the Jointed Test Finger shall be placed in every position as specified below:

Starting from the straight position, both joints of the test finger shall be rotated progressively through an angle of up to 90° with respect to the axis of the adjoining section of the finger and shall be placed in every possible position.

Internal barriers are considered part of the enclosure, if appropriate a low-voltage supply

(> 40 V and < 50 V) in series with a suitable lamp should be connected, between the JTF and high voltage live parts inside the electrical protection barrier or enclosure.

B-4.1 Acceptance Conditions

The requirements of **5.5.1.3** shall be considered to be met, if the JTF described in Fig. 9 is unable to contact high voltage live parts. If necessary a mirror or a fiberscope may be used in order to inspect whether the JTF touches the high voltage buses. If this requirement is verified by a signal circuit between the JTF and high voltage live parts, the lamp shall not light.

B-5 ISOLATION RESISTANCE

The isolation resistance between the high voltage bus and the electrical chassis may be demonstrated either by measurement or by a combination of measurement and calculation. The following instructions should be used, if the isolation resistance is demonstrated by measurement:

a) Measure and record the voltage (V_b) between the negative and the positive side of the high voltage bus (*see* Fig. 5);

b) Measure and record the voltage (V_1) between the negative side of the high voltage bus and the electrical chassis (*see* Fig. 5); and

c) Measure and record the voltage (V_2) between the positive side of the high voltage bus and the electrical chassis (*see* Fig. 5).

If $V_1 \geq V_2$, insert a standard known resistance (R_o) between the negative side of the high voltage bus and the electrical chassis. With R_o installed, measure the voltage (V_1') between the negative side of the high voltage bus and the vehicle electrical chassis (*see* Fig.7). Calculate the isolation resistance (R_i) according to the formula below:

$R_i = R_o * (V_b/V_1' - V_b/V_1)$ or $R_i = R_o * V_b * (1/V_1' - 1/V_1)$

Divide the result R_i, which is the electrical isolation resistance value, in Ω, by the working voltage of the high voltage bus, in volt (V).

R_i (Ω / V) = R_i (Ω) / Working voltage (V)

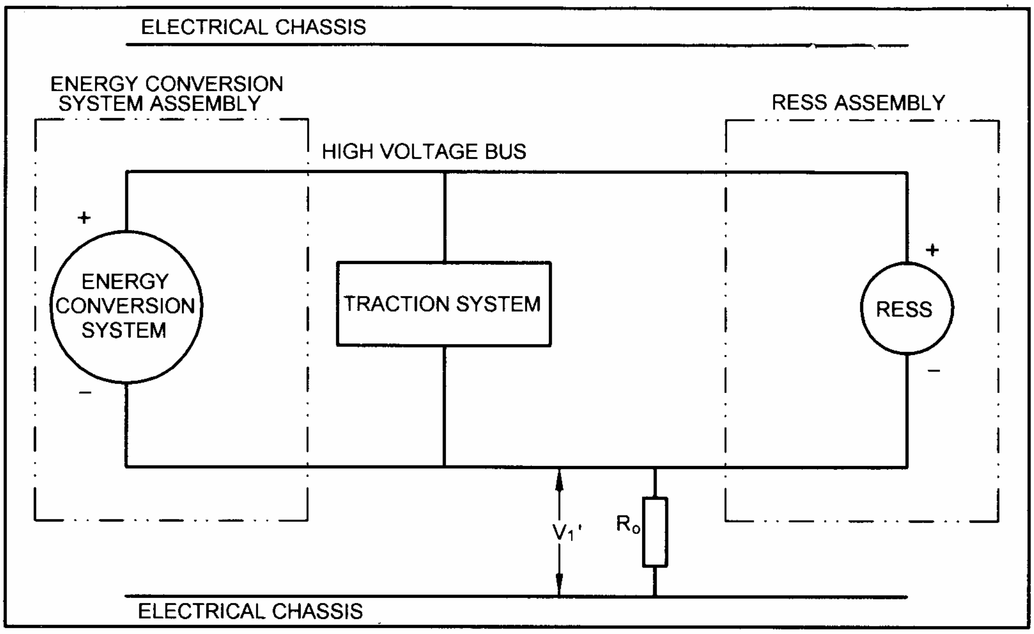


FIG. 7 MEASUREMENT OF V_1'

If $V_2 > V_1$, insert a standard known resistance (R_o) between the positive side of the high voltage bus and the electrical chassis. With R_o installed, measure the voltage (V_2') between the positive side of the high voltage bus and the electrical chassis (*see* Fig. 8).

Calculate the isolation resistance (R_i) according to the formula shown below.

$R_i = R_o*(V_b/V_2' - V_b/V_2)$ or $R_i = R_o*V_b*(1/V_2' - 1/V_2)$

Divide the result R_i, which is the electrical isolation resistance value (in Ω), by the working voltage of the high voltage bus, in volt (V).

R_i (Ω / V) = R_i (Ω) / Working voltage (V)

NOTE — The standard known resistance *R*o (Ω) should be the value of the minimum required isolation resistance (Ω /V) × the working voltage of the vehicle ±20 percent. *R*o is not required to be precisely this value since the equations are valid for any *R*o; however, an *R*o value in this range should provide a good resolution for the voltage measurements.

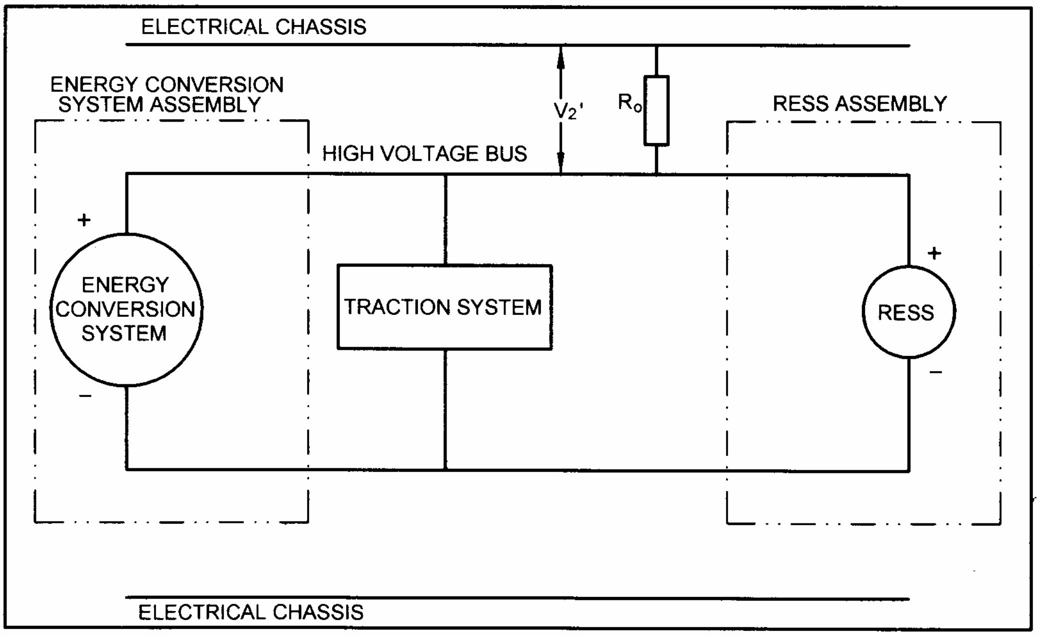


FIG. 8 MEASUREMENT OF V_2'

B-6 ELECTROLYTE SPILLAGE

Appropriate coating shall be applied, if necessary, to the physical protection in order to confirm any electrolyte leakage from the REESS after the impact test.
Unless the vehicle manufacturer provides means to differentiate between the leakage of different liquids, all liquid leakage shall be considered as the electrolyte.

B-7 REESS RETENTION

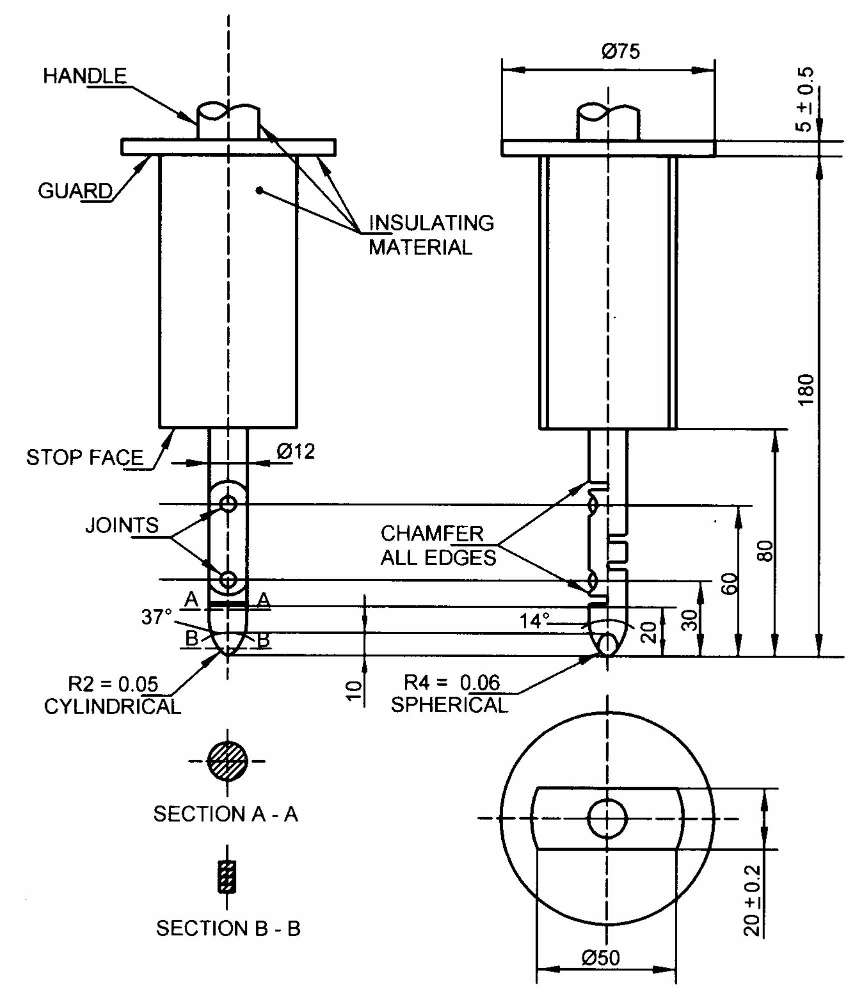
Compliance shall be determined by visual inspection.

ANNEX C

(*Clauses* B-4 and B-4.1)

JOINTED TEST FINGER – JTF (IPXXB)

C-1 DESCRIPTION OF JOINTED TEST FINGER – JTF (IPXXB)



NOTES

1 Material: metal, except where otherwise specified.

2 Linear dimensions in millimetre.

3 Tolerances on dimensions without specific tolerance:

(a) on angles: $^{0}_{-10°}$

(b) on linear dimensions: up to 25 mm : $^{0}_{-0.05}$ mm, over 25 mm: ±0.2 mm.

4 Both joints shall permit movement in the same plane and the same direction through an angle of 90° with a 0 to +10° tolerance.

FIG. 9 JOINTED TEST FINGER (JTF)

(TED 29)

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